U 2 **OBU Transmitter Spectrum Mask**

Maximum power (density) as function of the frequency emitted by the OBU transmitter.

U 3 **RSU Minimum Receiver RF Bandwidth**

Minimum range of frequencies which has to be received by the RSU receiver.

U 4 **Maximum Single Side band E.I.R.P.**

Maximum E.I.R.P. transmitted by the OBU outside the vehicle within a single side band, measured at the maximum incident power within the communication zone. The value is normally expressed in dBm. 0 dBm equals 1 mW. All power values are referred to an isotropic antenna.

U 5 **Antenna Polarisation** Refer to D 5

U 5a **Cross Polarisation** Refer to D 5a

U 6 **Sub-Carrier Modulation**

Keying of the sub-carrier wave by coded data. Some examples are Amplitude Shift Keying (ASK), Phase Shift Keying (PSK), and Frequency Shift Keying (FSK).

U 6a **Data Modulation Order**

Number (M) of different amplitude levels for ASK, the number of phase states for PSK and the number of frequencies for FSK. Normally the carrier is modulated by digital symbols. Each symbol represents a combination of k bits which allow to represent $M=2^k$ different states. The modulation order is equal to this number M.

U 6b **Eye Pattern / Duty Cycle**

For the definition of eye pattern, refer to D6b. Duty cycle: The ratio of the length of high or low pulses to the duration of a complete cycle.

U 6c **Modulation on Carrier**

Keying of the carrier wave by the modulated sub-carrier.

U 6d **Side Band Suppression**

Level of suppression of the unused side band relative to the used side band.

U 6e **Side Band Isolation**

Minimum suppression of the side band modulated with data stream 1 relative to the side band modulated with data stream 2.

U 7 **Data Coding** Refer to D 7

U 8 **Symbol Rate**

Number of symbols per second. This is independent of the data coding. The corresponding bit rate is larger by a factor of ld(M), where ld() is the logarithm to base 2.

Unit used: 1 baud = 1 symbol/s

U 8a **Tolerance of Symbol Clock** Refer to D 8a

U 9 **Bit Error Rate** Refer to D 9

U 11 **Power Limits within Communication Zone.**

CW Power produced by the RSU which allows the reference OBU defined by U12 to have a transmit power E.I.R.P. of a sufficient level to allow the RSU to receive with a B.E.R. not exceeding reference value defined by U9. This parameter is not directly measured.

U 12 **Minimum Conversion Gain**

Difference between OBU E.I.R.P. within one side band and carrier power incident on OBU. Power is measured outside the vehicle. Measured at the minimum incident power within the communication zone.

Remark: Minimum Conversion Gain is equal to two times the OBU antenna gain minus the OBU losses minus two times the windscreen losses. Windscreen losses depend on the material of the windscreen and on the installation geometry.

U 13 **Preamble / Postamble** Refer to D 13

U 13a **Preamble Length and Pattern**

The Preamble Length is measured either in multiples of symbols or in seconds. The Preamble Pattern is a detailed specification of the shape of the preamble signal as it is on the channel after coding.

U 13b **Postamble Length and Pattern**

The Postamble Length is measured either in multiples of symbols or in seconds. The Postamble Pattern is a detailed specification of the shape of the preamble signal as it is on the channel after coding.

3.3 Definition for Interface Parameters to DSRC Data Link Layer

Parameters defined in this subsection apply to the interface between Layer 1 and 2 of the DSRC link.

D/U14 **Link Turn Around Time**

The time requested by Layer 1 to process a frame minus the time defined by the symbol / bit rate and the frame length as prepared by Layer 2. This maximum time is important for the higher layers. If time is given in multiples of the bit / symbol duration the appropriate bit / symbol rate has to be chosen, i.e. D8 for D14a/b and U8 for U14a/b. Four different values are defined below.

D14a $RLTA_{rt}$: **RSU Link Turn Around from receive mode to transmit mode**

The time necessary at the RSU to switch from receive mode to transmit mode.

D14b **$OLTA_{tr}$: OBU Link Turn Around from transmit mode to receive mode**

The time necessary at the OBU to switch from transmit mode to receive mode.

U14a **$OLTA_{rt}$: OBU Link Turn Around from receive mode to transmit mode**

The time necessary at the OBU to switch from receive mode to transmit mode.

U14b **$RLTA_{tr}$: RSU Link Turn Around from transmit mode to receive mode**

The time necessary at the RSU to switch from transmit mode to receive mode.

D22 **Minimum Frame Length for OBU Wake-Up.**

Minimum length of a frame, including header, necessary to wake up the OBU.

D22a **OBU Time Out**

Minimum time OBU must stay in wake up state without receiving data.

3.4 Symbols

$M=2^k$	Number of symbols
k	Number of bits per symbol
P	Power

3.5 Abbreviations

AM	Amplitude Modulation
ASK	Amplitude Shift Keying
B.E.R.	Bit Error Rate
CW	Continuous Wave
DSRC	Dedicated Short-Range Communication
E.I.R.P.	Equivalent Isotropic Radiation Power
ERC	European Radiocommunications Committee
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiple Access
FM0 / FM1	Bi-phase coding scheme, bit inverse to FM1 / FM0
FSK	Frequency Shift Keying
NRZ	Non Return to Zero
NRZI	Differential version of NRZ
OBU	On-board Unit, often referred to as transponder
OSI	Open Systems Interconnection
ppm	Parts per million ($= 10^{-6}$)
PSK	Phase Shift Keying
RF	Radio Frequency
RSU	Road Side Unit
SDMA	Space Division Multiple Access
TDMA	Time Division Multiple Access
XPD	Cross Polar Discrimination. Ellipticity of Polarisation.

4 REQUIREMENTS (Normative)

4.1 Downlink Parameters

Table 1 below defines the relevant downlink OSI Layer 1 parameters. Initialisation of any communication shall be performed by using the given default values. On-line negotiations, performed by higher DSRC communication layers, may result in utilisation of options values.

The parameters which have been marked with an asterisk (*) are subject to legal type approval requirements. These parameters are specified in ETSI standard prI-ETS 300 674. Equipment meeting the requirements of the ETSI standard shall simultaneously satisfy the comparable requirements of this CEN standard. Therefore these parameters have the same value in each standard.

The parameters marked with an asterisk (*) have been set by mutual agreement between ETSI and CEN to achieve efficient use of the radio spectrum and acceptable performance for a short-range communication link, together with other performance requirements set out in this CEN standard. These parameters cannot be changed by either ETSI or CEN without the simultaneous agreement of each organisation.

Table 1: Downlink parameters

Item no.	Parameter	Values:	
		Default	**Options**
D 1 (*)	Carrier Frequencies	Two downlink channels at: (centre frequency) ± Δf.	Defined by installation (and due to negotiations):
		Centre frequency of allocated CEPT band: 5.8 GHz	Other 10 MHz band within the same ISM band allocated for RTT on a national basis.
		Δf = 2.5 MHz	Needs one bit for coding. 0 European band 1 National band Management not defined by Layer 1.
D 1a (*)	Tolerance of Carrier Frequencies	within ± 5 ppm	-

D 2 (*)	RSU Transmitter Spectrum Mask	(1) Out band power: ≤ -30 dBm (2) In band power: ≤ +33 dBm (3) Spurious emission for unmodulated carrier wave shall be less than: Co-channel uplink @ 1.5 MHz: ≤ - 27 dBm in 500 kHz. Co-channel uplink @ 2.0 MHz: ≤ - 27 dBm in 500 kHz. Adjacent channel uplinks: ≤ - 47 dBm in 500 kHz. (4) For in band spurious emission with modulated carrier wave, three different requirement classes are defined: ***Class A:*** Co-channel uplink @ 1.5 MHz: ≤ -7 dBm in 500 kHz. Co-channel uplink @ 2.0 MHz: ≤ -27 dBm in 500 kHz. Adjacent channel uplinks: ≤ -30 dBm in 500 kHz. ***Class B:*** Co-channel uplink @ 1.5 MHz: ≤ -17 dBm in 500 kHz. Co-channel uplink @ 2.0 MHz: ≤ -27 dBm in 500 kHz. Adjacent channel uplinks: ≤ -37 dBm in 500 kHz. ***Class C:*** Co-channel uplink @ 1.5 MHz: ≤ -27 dBm in 500 kHz. Co-channel uplink @ 2.0 MHz: ≤ -27 dBm in 500 kHz. Adjacent channel uplinks: ≤ -47 dBm in 500 kHz. (Equipment complying with the different classes will require different re-use distance as described in Annex B)	-
D 3	OBU Minimum Receiver Bandwidth	At least CEPT band 5.8 GHz ± 5 MHz	National band within same ISM band
D 4 (*)	Maximum E.I.R.P.	≤ +33 dBm	-

D 4a	Angular E.I.R.P mask	$\Theta \leq 70^{o}$: ≤ +33 dBm $\Theta > 70^{o}$: ≤ +18 dBm	-
D 5 (*)	Antenna Polarisation	Left hand circular	-
D 5a	Cross Polarisation	XPD: In boresight: $RSU_t \geq 15$ dB $OBU_r \geq 10$ dB At -3 dB area: $RSU_t \geq 10$ dB $OBU_r \geq 6$ dB	-
D 6 (*)	Modulation	Two level amplitude modulation.	-
D 6a (*)	Modulation Index	0.5 ... 0.9	-
D 6b (*)	Eye Pattern	≥ 90 % (time) / ≥ 85 % (amplitude)	-
D 7 (*)	Data Coding	FM0 "1" bit has transitions at the beginning and end of the bit. "0" bit has an additional transition in the middle of the bit compared to the "1" bit.	Defined by installation (and due to negotiations): NRZI. Management not defined by Layer 1 Code: 0 FM0 1 NRZI
D 8 (*)	Bit rate	500 kBit/s	Defined by installation (and due to negotiations): Coded in 3 bit: 000 res. for future use ~~001 31.25 kBit/s~~ ~~010 62,5 kBit/s~~ ~~011 125 kBit/s~~ ~~100 250 kBit/s~~ 101 500 kBit/s 110 1000 kBit/s 111 res. for future use (Every bit rate has to comply with D2)
D 8a	Tolerance of Bit Clock	better than 100 ppm	-
D 9	Bit Error Rate B.E.R.	Only reference value: 10^{-6}	-
D 10	Wake-up process for OBU	Wake-up process on ordinary data.	-
D 10a	Maximum Start Time	≤ 5 ms	-
D 11 (*)	Power Limits within Communication Zone	Min. incident power: -40 dBm Max. incident power: -14 dBm	-
D 13	Preamble	Preamble is mandatory	-
D 13a	Preamble Length	16 bit ± 1 bit	-

D 13b	Preamble Wave form	An alternating sequence of low level and high level with pulse duration of 2 µs.	-

(*) - Downlink parameters subject to Type Approval. Refer to explanation above.

4.2 Uplink Parameters

Table 2 defines relevant uplink DSRC Layer 1 parameters. Initialisation of any communication shall be performed by using the given default values. On-line negotiations, performed by higher DSRC layers, may result in utilisation of options values.

The parameters which have been marked with an asterisk (*) are subject to legal type approval requirements. These parameters are specified in ETSI standard prI-ETS 300 674. Equipment meeting the requirements of the ETSI standard shall simultaneously satisfy the comparable requirements of this CEN standard. Therefore these parameters have the same value in each standard.

The parameters marked with an asterisk (*) have been set by mutual agreement between ETSI and CEN to achieve efficient use of the radio spectrum and acceptable performance for a short-range communication link, together with other performance requirements set out in this CEN standard. These parameters cannot be changed by either ETSI or CEN without the simultaneous agreement of each organisation.

Table 2: Uplink parameters

Item no.	Parameter	Values	
		Default	Options
U 1 (*)	Sub-carrier Frequencies	1.5 MHz and 2.0 MHz	Defined by installation and due to negotiations.
U 1a	Tolerance of Sub-carrier Frequencies	within ± 0.1%	-
U 1b	Use of Side Bands	Same data on both sides or data only on upper side band will be allowed for default	Both side bands can be used independently. There are four possibilities coded as follows: 00 Reserved for future use 01 Same data in both side bands 10 Data only in upper side band 11 Different data in side bands.
U 1c	Tolerance of Direct Generated Uplink Carrier	same as D1a	-

U 2 (*)	OBU Transmitter Spectrum Mask	All values referred to outside the vehicle (1) Out band power ≤ -30 dBm in 1 MHz (2) In band power (adjusted) ≤ -24 dBm in 500 kHz (3) Spurious emission in any other uplink channel: -42 dBm in 500 kHz	-
U 3	RSU Minimum Receiver RF Bandwidth	CEPT-band 5.8 GHz ± 5 MHz	National band within same ISM band
U 4 (*)	Maximum Single Side band E.I.R.P.	≤ -24 dBm	-
U 5 (*)	Antenna Polarisation	Left hand circular	-
U 5a	Cross Polarisation	XPD: In boresight: $RSU_r \geq 15$ dB $OBU_t \geq 10$ dB At -3 dB: $RSU_r \geq 10$ dB $OBU_t \geq 6$ dB	-
U 6	Sub-Carrier Modulation	M-PSK Encoded data synchronised with subcarrier: Transitions of encoded data coincide with transitions of subcarrier.	-
U 6a	Data Modulation Order	M=2	Defined by installation and due to negotiations. 2 bit coded: 00 M = 2 01 M = 4 10 M = 8 11 reserved for future use
U 6b	Eye Pattern / Duty Cycle	Eye pattern: ≥ 90% / ≥ 90%; or Duty Cycle: 50% ± α, α ≤ 5%	-
U 6c	Modulation on Carrier	Multiplication of modulated sub-carrier with carrier.	-
U 6d	Side Band Suppression	≥ 60 dB	-
U 6e	Side Band Isolation	≥ 20 dB	-
U 7 (*)	Data Coding	NRZI (No transition at beginning of "1" bit, transition at beginning of "0" bit, constant level within bit)	-

U 8 (*)	Symbol Rate	250.000 baud	Defined by installation (and due to negotiations): Bit rate coded in 3 bit: 000 reserved for future use ~~001 31.25 kBit/s~~ ~~010 62.5 kBit/s~~ ~~011 125 kBit/s~~ ~~100 250 kBit/s~~ 101 500 kBit/s 110 750 kBit/s 111 reserved for future use (Every symbol rate has to comply with U2)
U 8a	Tolerance of Symbol Clock	0.1 % of used symbol rate	-
U 9	B.E.R.	Only reference value: 10^{-6}	-
U 11	Power Limits within Communication Zone	The CW Power produced by the RSU which allows the reference OBU defined by U12 to have a transmit power E.I.R.P. of a sufficient level to allow the RSU to receive with a B.E.R. not exceeding reference value defined by U9.	-
U 12 (*)	Minimum Conversion Gain	-5 dB for each used side band Range of angle: Circularly symmetric around bore sight $\pm 35^{o}$	-
U 13	Pre-/Postamble	Preamble is mandatory	-
U 13a	Preamble Length and Pattern	32 ... 40 µs modulated with subcarrier only, then 8 BPSK symbols with a phase shift at the beginning of every symbol.	-
U 13b	Postamble Length and Pattern	2 symbols of 1 bits in the chosen M-PSK mode + further 6 symbols to switch off and decrease the power level at least by 40 dB. The decreased power level has to be achieved at any time during these 6 further symbols.	-

(*) - Uplink parameters subject to Type Approval. Refer to explanation above.

4.3 Interface Parameters to DSRC Data Link Layer

Table 3: Interface Parameters, relevant for communication with DSRC Data Link Layer

Item number	Parameter	Values Default	Opt.
D 14a	$RLTA_{rt}$	Length of preamble for downlink + 1 bit	-
D 14b	$OLTA_{tr}$	100 bit	-
U 14a	$OLTA_{rt}$	Length of preamble for uplink + 1 bit	-
U 14b	$RLTA_{tr}$	100 bit	-
D 22	Minimum Frame Length for OBU Wake-Up	12 Byte	-
D 22a	OBU Time Out	100 ms subject to acceptance by higher layers	

Annex A: Bibliography (informative)

Table A1: Documents, served as references while preparing the standard

No.	Author(s)	Title
1	CEPT	"Procedures for Type Testing and Approval for radio equipment intended for non-public systems", CEPT Rec. T/R 71-03 E, 15.04.91.
2	ERC/CEPT	"Harmonisation of frequency bands for Road Transport Informatics Systems (RTI)", CEPT Rec. T/R 22-04E, Lisbon 1991.
3	ERC/CEPT	"Harmonisation of frequency bands to be designated for Road Transport Telematics Systems", ERC Report 3.

Table A2: Documents, which can provide further insight into the evolution of the standard

No.	Author(s)	Title
I-1	CEN TC278 WG9	"1st Status Report to CEN / TC278", CEN TC278 WG9 doc. #35, 1993-04-03
I-2	H J Fischer, DASA (editor)	"DSRC - 5.8 GHz Layer 1, First Report to CEN TC278", CEN M018 PT06, doc. 2-25, 1994-07-25
I-3	H J Fischer, DASA (editor)	"Document Register", CEN M018 PT06, doc. 2-1, Version 1.8, 1994-07-29.

Annex B: Installation and re-use distance of DSRC equipment (Informative)

To enable interoperability between different DSRC equipment fulfilling the requirements of this Prestandard, it is believed to be necessary to consider also the installation requirements. Such installation requirements may distinguish between different RTTT applications. Considering e.g. Automatic Fee Collection or Automatic Vehicle Identification, the OBU antenna could be installed in the centre of the vehicle, possibly behind the rear mirror. The direction of the OBU antenna should be matched to the intended configuration of the DSRC communication zone.

The installation geometries to some extent also influence the aspect of minimum re-use distance between independent, non-synchronised communication channels caused by interference. The re-use distance is also dependent on specific implementation parameters such as RSU antenna gain and RSU transmitter spectrum mask class (Section 4.1, Requirement D2). In the preparation of this Prestandard, re-use distances were calculated using a free-space propagation model, even though under specific circumstances shorter re-use distances may be attained

As an illustration of the free-space model prediction results, Table B1 below shows calculated non-synchronised re-use distances based on the following assumptions:

(1) The RSU transmits with maximum E.I.R.P (see parameter D4).

(2) The OBU transmits with maximum E.I.R.P. (see parameter U4).

(3) The maximum allowed interference level for uplink receiver is -135 dBm (assuming RSU antenna gain of approximately 20 dB).

(4) The RSU antenna provides a side lobe suppression of 15 dB.

(5) The maximum allowed interference level for the downlink receiver is - 60 dBm.

Based upon these assumptions and free-space propagation, calculated re-use distances for the three classes of RSU transmitter spectrum mask are presented in Table B1.

Table B1: Calculated re-use distances

Interference path	Class A	Class B	Class C
Downlink on uplink			
co-channel at 1.5 MHz	330 m	105 m	35 m
co-channel at 2.0 MHz	35 m	35 m	35 m
adjacent channels	25 m	10 m	3 m
Downlink on downlink			
same channel		35 m	
other channel		negligible	
Uplink on uplink			
same channel		260 m	
other channel		35 m	
Uplink on downlink		negligible	

Annex C: Link budget related parameters (Informative)

In the preparation of this Prestandard, link budget related parameters were defined in a way to make them independent of application specific conditions. Specifically in RTTT applications, values given for the following parameters should be referred to the outside of the vehicle:

D 11: Communication Zone

U2: OBU Transmitter Spectrum Mask

U4: Maximum Single Side band E.I.R.P.

U11: Communications Zone.

U12: Minimum Conversion Gain.

Relevant attenuation factors have to be considered in each particular case in order to comply with these parameter specifications.

As an example, the following calculations were made in the case of parameter U12 Minimum Conversion Gain:

Table C1: Conversion Gain Budget

OBU antenna gain 35 degrees off boresight.	4 dB
Windscreen loss, one way	3 dB
Loss per side band	3 dB
Realisation margin (OBU losses, manufacturing tolerances...)	4 dB

In this example the resulting minimum conversion gain, calculated as two times the OBU antenna gain minus two times the windscreen loss minus OBU losses will be -5 dB for each side band, as specified in U12.

APPENDIX C:
Committee of Japan Physical Layer Standard

DRAFT

October 1997

Transport Information and Control System (TICS)
Dedicated Short-range Communication (DSRC)
DSRC Physical Layer using Microwave at 5.8GHz
High Data Rate

This draft standard has been drawn up by ISO TC204 WG15 Committee of Japan, Subgroup Layer 1 Project Team. After proper comments, revisions, and approval, it is intended to be submitted to ISO for formal vote.

Version 4.0

ISO TC204 WG15
Committee of Japan

DRAFT
prTR2/204/15/#xx Version 4.0
October 06, 1997

Transport Information and Control System (TICS)
Dedicated Short-range Communication (DSRC)
DSRC Physical Layer using Microwave at 5.8GHz High Data Rate

Foreword

This international pre-standard has been prepared by Japanese project team WG15/PT-L1 for SG.L1 as a sub-group of ISO TC204 Working Group 15 (WG15).
The following pre-standards will be provided in addition to a series of pre-standards that define Dedicated Short Range Communication (DSRC) in the TICS environment by the Japanese project team to establish a complete set of pre-standards for the DSRC link.

List of pre-standard and technical report concerning DSRC:
prTR2/204/15/#xx "DSRC Data Link Layer at HDR" (*)
prTR2/204/15/#xx "DSRC Application Layer at HDR" (*) (*): Separate document

The technical report CEN prENV 278/9/#61 "DSRC Summary Report" issued in October 1995 has been referred to for requirements of TICS applications and basic matters related to the DSRC concept.
DSRC standards also include CEN ENV 278/9/#61 to 65 prepared by CEN TC278 WG9 SG.L1 and CEN TC278 M018 PT06. These pre-standards have been adopted by NP/CD voting.
The Japanese project team WG15/PT-L1 mainly consists of experts in the communication sector. The member companies and organizations are as follows:

Sumitomo Electric Industries, Ltd., Matsushita Communication Industrial Co., Ltd., Mitsubishi Heavy Industries, Ltd., Toshiba Corporation, NEC Corporation, Hitachi, Ltd., Mitsubishi Electric Corporation, Oki Electric Industry Co., Ltd., Toyota Motor Corporation, Nissan Motor Co., Ltd., Denso Corporation, Japan Highway Public Corporation, Metropolitan Expressway Public Corporation, Hanshin Expressway Public Corporation, and Highway Telecom Engineer Co Ltd

ITU-R SG8 WP8A has been deliberating on the technical standard recommendations for the Transport Information and Control Systems (TICS), which may partially be duplicated with the pre-standard. Since this pre-standard assumes to conform to the ITU-R recommendations as soon as they are provided, it will be revised again. Cooperation and comments from experts in Europe were obtained in CEN TC278 WG9, and cooperation from ITS America and ASTM was obtained in ISO TC204 WG15.

Introduction

Dedicated Short Range Communication is intended to be a communication means for Transport Information and Control Systems (TICS) and Road Traffic and Transport Telematic (RTTT) applications, amongst others such as Automatic Fee Collection (AFC), Automatic Vehicle and Equipment Identification (AVI/AEI) and Traffic and Traveler Information (TTI).

This international pre-standard comprises performance requirements Open Systems Interconnection (OSI) Layer 1 at 5.8 GHz for DSRC. This international pre-standard does not include associated measurement procedures for verification of the requirements. Measurement guidelines are intended to be developed in ISO TC204 WG15, together with ITU-R SG8 WP8A DG8A-5, as a separate work item.

This international pre-standard is based on transceiver technologies, which is different from the European Pre-Standard prepared by CEN TC278 WG9 SG.L1. In other words, There basically is no interoperability between them. This international pre-standard is aimed at high-speed data transmission in a wide communication zone with mixed time and frequency division multiple access approaches to freely running vehicles.

This international pre-standard is conceived for the 60MHz part of the ISM band at 5.8 GHz which will be recommended by ITU-R. It is recommended to require the exclusive use of this part of the band, considering the probability of interference caused by other non-DSRC systems. With regard to the channel plan, two wave pairs not dependent on the number of lanes, or 4 channels for both the road and vehicles, are specified to be allocate. An additional sub-band, however, may be allocated in some countries, depending on the distance between RSUs or the influence of neighboring structures.

Title:

a) Dedicated Short-Range Communication
b) Transport Information and Control Systems
c) Road Traffic and Transport Telematics
d) Automatic Fee Collection
e) Automatic Vehicle and Equipment Identification
f) Traffic and Traveller Information
g) DSRC Physical Layer using Microwave at 5.8 GHz. HDR

1. Scope

This international pre-standard ...

- establishes a common framework for physical layer at 5.8 GHz for DSRC for the TICS sector.
- provides requirements for the communication medium to be used for exchange of information between road-side units (RSU) and on-board units (OBU).
- does not include associated measurement guidelines for verification of the formulated requirements in this pre-standard.
- *does not consider any one specific TICS application, but rather caters for a* communication means to be used by several applications in the TICS sector.

In the physical layer at 5.8 GHz, communication requirements for the information from the RSU to the OBU are defined as downlink parameters while the requirements associated with the information from the OBU to the RSU are defines as uplink parameters.

2. Normative References

This international pre-standard incorporates, by dated and undated references, provisions from other publications. For dated references, the most recent amendment to or revision of any of these publications apply to this international pre-standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

No.	Source organization	Title
1		
2		
3		

2.1 Relationship with Other Standards

Certain parameters in this international pre-standard are set by mutual agreement with ITU. The relevant standard are pr-ITU-R ***** and pr-XXX-****.

3. Definitions, Symbols and Abbreviations

3.1 Definitions for Downlink Parameters

Downlink parameters shall apply to data transmission from RSU to OBU. The parameters are defined as follows for the sake of this standard:

D1 Carrier Frequencies
Center frequency of the downlink band for transmission from RSU

D1a Alienate Frequencies of Transmitter from Receiver
OBU can transmit information at a frequency alienated from that from RSU.

D1b Allowable Deviation of Carrier Frequencies
Maximum deviation of the carrier frequency caused by any impact. It is expressed in parts per million.
Example: 1 ppm of a 5.8 GHz carrier allows for the carrier frequency to be in the range of 5.8 GHz $\pm$ 5.8 KHz.

D2 RSU Transmitter Spectrum Mask
Maximum power emitted by the RSU transmitter as a function of the frequency

D2a Occupied Bandwidth
The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage B/2 of the total mean power of a given emission.
Unless otherwise specified by the CCIR for the appropriate class of emission, the value of B/2 should be taken as 0.5%.

D3 OBU Receiver Bandwidth
3 dB bandwidth of OBU receiver

D4 Maximum E.I.R.P.
Power supplied to an antenna multiplied by the absolute gain of the antenna in a given direction is called Equivalent Isotropic Radiation Power (E.I.R.P.) and an E.I.R.P. of the antenna directed to a maximum radiated power is called Maximum E.I.R.P. The value is normally expressed in dBm. 0 dBm equals 1 mW. RSU is classified according to the transmission distance.
Class 1: For a transmission distance of 10 m or less
Class 2: For a transmission distance of 30 m or less

D4a Angular E.I.R.P. Mask
Maximum E.I.R.P. as a function of the angle Θ, where Θ indicates the angle relative to a vector perpendicular to the road surface, pointing downwards.

D5 Antenna Polarization

Locus of the tip of the of the electric field vector in a plane perpendicular to the transmission vector. Examples are horizontal and vertical linear polarization and left and right hand circular polarization. Circular polarization is polarization of a circle that rotates clockwise (or counterclockwise) with time lapse as seen from the rear side of the antenna.

D6 Modulation

Keying of the carrier wave by coded data. Some examples are amplitude shift keying (ASK), phase shift keying (PSK), frequency shift keying (FSK) and linear amplitude modulation (AM).

D6a Modulation Index

Size of the variation of the modulation parameter (frequency, amplitude, phase) caused by the modulation signal (data signal). It is expressed as follows in ASK.

Modulation index = (Vmax-Vmin) / (Vmax+Vmin)

where, Vmax : crest of amplitude waveform after detection by diode, Vmin : bottom of amplitude waveform after detection by diode.

D6b Eye Pattern

Free decision distance in width and height of a digital signal. An ideal digital signal has a decision height of 100% which is equal to the difference of high level and low level. Considering e.g. bi-phase coding, the ideal (=100%) distance in width is equal to half the bit duration.

Eye pattern(amplitude) = 2B/(A+B) where, A:max.amplitude, B:min.amplitude.

Eye pattern(time) = 2B'/(A'+B') where, A':max.zero-cross time width, B':min.zero-cross time width.

D7 Data Coding

Baseband signal representation, i.e. a mapping of logical bits to physical signals. For data bit "1" in the case of ASK Manchester coding, the RF signal is sent in the first half of the bit duration and the RF signal is not sent in the latter half. For data bit "0", the RF signal is not sent in the first half and sent in the latter half of the bit duration.

D8 Bit Rate

Number of bits per second, independent of the data coding.

Examples: 1 Mbps, 500 Kbps and 250 Kbps

D8a Tolerance of Bit Clock

Max. deviation of the bit clock caused by any impact, expressed in ppm or %.

D9 Bit Error Rate (B.E.R.)

Averaged number of erroneous bits related to all transmitted bits. Used only as a reference value for layer 1. The realized B.E.R. depends on the modulation-demodulation system, C/N, Eb/No and fading, and no specific distribution of errors is taken into consideration. The effective B.E.R. within the communication zone may be different to the reference value due to the place and time variants as well as stochastic impacts.

Example: Generally represented in 10^{-5} or 10^{-6}.

D10 Wake-up Process for OBU

Process within the OBU which ...

(1) indicates to the OBU that it is within a communication zone, i.e., that it may now communicate with a RSU.

(2) switches the OBU main circuitry from standby mode (sleep mode) to the active mode. This is a feature to allow the OBU to save battery power. It is not mandatory for an OBU to use a wake-up process.

D10a *Maximum Start Time*

Maximum time between the reception within the communication zone of a downlink message of minimum length, and the time when the OBU has switched to the active mode and is ready for operation

D11 Power Limits within Communication Zone

Minimum and maximum values of incident power referred to the 0 dBi antenna in front of OBU. These two values also specify the dynamic range of the OBU receiver. Power values are measured without any additional losses due to rain or misalignment.

D12 Burst Transmission Transient Response Time

Time after the power at the time of carrier off until the end of transient response or after the start of transient response to the power at the time of carrier off for on/off of the burst wave modulated by the digital signal from the RSU.

D13 Allowable Deviation of Absolute Signal Transmission Time

Deviation of the time after the start of RSU control signal (FCM) transmission until the end of final slot reception from the reference time.

D15 Leakage Power in Standby mode

Leakage power from RSU in standby mode.

D16 Spurious Response

Difference between the levels of operation +3dB and the interference level when B.E.R. of OBU is prescribed value .

3.2 Definitions for Uplink Parameters

Uplink parameters apply to transmission from OBU to RSU. For the purpose of this standard, the following definitions apply:

U1 Carrier Frequencies
Center frequencies of uplink bands for transmission from OBUs. Each OBU uses a frequency with a given offset from the downlink carrier frequency from the RSU.
The relation between the U1 and D1 frequencies is as follows:
U1 = D1 + U1a or U1 = D1 - U1a

U1a Alienate Frequencies of Transmitter from Receiver
Difference between OBU carrier frequency (U1) and RSU carrier frequency (D1). This corresponds to the necessary frequency offset dependent on the OBU filter performance to allow the RSU to perform full-duplex communication with the OBU. It should generally be approx. 40 MHz.

U1b Allowable Deviation of Carrier Frequencies
Refer to D1b.

U2 OBU Transmitter Spectrum Mask
Maximum power as a function of the frequency emitted from the OBU transmitter.

U2a Occupied Bandwidth
Refer to D2a.

U3 RSU Receiver Bandwidth
3 dB bandwidth of the RSU receiver

U4 Maximum E.I.R.P.
Power supplied to an antenna multiplied by the absolute gain of the antenna in a given direction is called Equivalent Isotropic Radiation Power (E.I.R.P.) and an E.I.R.P. of the antenna directed to a maximum radiated power is called Maximum E.I.R.P. The OBU is not classified. The value is normally expressed in dBm. 0 dBm equals 1 mW.

U5 Antenna Polarization
Refer to D5.

U6 Modulation
Refer to D6.

U6a Modulation Index
Refer to D6a.

U6b Eye Pattern
Refer to D6b.

U7 Data Coding
Refer to D7.

U8 Bit Rate
Refer to D8.

U8a Tolerance of Bit Clock
Refer to D8a.

U9 Bit Error Rate (B.E.R.)
Refer to D9.

U11 Power Limits within Communication Zone
Minimum and maximum values of incident power referred to the 0 dBi antenna at the RSU. These two values also specify the dynamic range of the RSU receiver. Power values are measured without any additional losses due to rain or misalignment.

U12 Burst Transmission Transient Response Time
Refer to D12.

U13 Allowable Deviation of Absolute Signal Transmission Time
Deviation of the time after the end of RSU control signal (FCM) reception until the start of OBU connection response from the reference time.

U14 Transmission / Reception Turn Around Time
The time necessary at the OBU to switch from transmit mode to receive mode, or from receive mode to transmit mode.
This time may include U12.

U15 Leakage Power in Standby mode
Refer to D15.

U16 Spurious Response
Refer to D16.

U17 Frequency Selecting Process
Process for OBU to receive the signal from RSU in communication zone and select the frequency to be used in OBU. Some available methods are two receiving frequency method, wide-band IF method, high-speed switch method, and the method for obtaining the selection information from the most recently received RSU information.

U17aFrequency selecting time
Time required for the frequency selecting process in the OBU. This value, however, includes the time for OBU wake-up or antenna switch-over, if any.

U18 Call Sign Transmission Process
Transmission process of a code given as the identification signal of a radio station to identify that OBU is a DSRC radio station. This process differs by the country and/or area.

3.3 Symbols

dBm

dBi

ppm Parts per million ($=10^{-6}$)

3.4 Abbreviations

ASK	Amplitude Shift Keying
ASTM	American Society for Testing and Materials
B.E.R.	Bit Error Rate
CEN	Committee European de Normalization
CW	Continuous Wave
DSRC	Dedicated Short-Range Communication
E.I.R.P.	Equivalent Isotropic Radiation Power
ETC	Electronic Toll Collection system
ETSI	European Telecommunications Standards Institute
ETTM	Electronic Toll & Traffic Management
FDMA	Frequency Division Multiple Access
HDR	High Data Rate
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Bureau
OBU	On-Board Unit
OSI	Open Systems Interconnection
RF	Radio Frequency
RSU	Road Side Unit
RTTT	Road Traffic and Transport Telematics
SDMA	Space Division Multiple Access
TDMA	Time Division Multiple Access
TICS	Transport Information and Control Systems